

# Enhancing Student Engagement and Knowledge Acquisition in Chemistry Through Nanolearning Instructional Materials

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**Abstract**—This study explored the use of nanolearning in enhancing student engagement and knowledge acquisition in Chemistry, assessing their acceptance in content, format, conciseness, and usability. It measured cognitive, behavioral, and emotional engagement and knowledge levels in control and experimental groups, and tested for significant differences. The researcher used a quasi-experimental design with 80 Grade 8 students split into control and experimental groups via stratified random sampling. Validated nanolearning materials, surveys, and assessments measured engagement and knowledge on a 5-point Likert scale. Data from science tests were analyzed using mean, standard deviation, and *t*-tests to identify significant differences. The study revealed a high level of acceptance of the material in terms of content, format, conciseness, and usability. Additionally, the experimental group demonstrated greater involvement in the cognitive, behavioral, and emotional aspects. Both groups demonstrated comparable levels of prior knowledge based on initial science competency tests. However, after exposure to nanolearning, the experimental group showed marked improvement in their scores on the end-of-instruction science test. A significant difference in student engagement was found, with the experimental group exposed to nanolearning materials demonstrating higher cognitive, behavioral, and emotional engagement. Moreover, the initial science competency test showed no significant difference in prior Chemistry knowledge between the control and experimental groups. However, students in the experimental group, who used nanolearning instructional materials have higher scores in end-of-instructions. The researcher therefore concluded that students who used nanolearning instructional materials showed significantly higher levels of engagement in Chemistry in three dimensions, leading to the rejection of the null hypothesis on engagement. No significant difference was found in the initial science competency test. However, an improvement in knowledge acquisition was observed in the experimental group by the end-of-instruction test. Based on the findings, it is recommended to integrate nanolearning materials in Chemistry instruction to enhance student engagement and knowledge acquisition through focused, interactive, and emotionally engaging content. Further studies are encouraged to examine the long-term impact of nanolearning across different subjects.

**Keywords**— Nanolearning, student engagement, knowledge acquisition, science tests, instructional materials.

## I. INTRODUCTION

In recent years, educational technology has evolved rapidly, introducing new methodologies designed to meet the changing needs of 21st-century learners. One such approach is nanolearning, a type of microlearning that provides bite-sized,

focused educational content in short, easily digestible segments (Subramani, 2024). As digitalization increases, particularly in educational settings, nanolearning has garnered attention as an effective approach that aligns with the learning habits of learners who are accustomed to short-form content on digital platforms (Timotheou et al., 2022). Chemistry is often viewed as a challenging subject because of its abstract concepts, which demand cognitive load, and this teaching method could greatly benefit the subject as well as the teachers.

Despite its potential, learners' engagement in Chemistry classes remains a concern. Studies indicate that traditional teaching methods often struggle to capture and maintain learners' attention, particularly with complex subjects like Chemistry, which require deeper understanding. (Azumah et al., 2023). In Chemistry education, students frequently find it difficult to grasp difficult concepts and detailed content. Nanolearning presents a valuable solution to enhance both student engagement and knowledge acquisition. Research indicates that student engagement is essential for achieving successful learning outcomes, especially in subjects like Chemistry which demand a thorough understanding of both theoretical principles and their practical applications (Demelash et al., 2024). Nanolearning allows teachers to present these ideas in smaller, more focused lessons, making it easier for students to absorb and retain information. It is important to support teaching and learning process with the appropriate and effective instructional materials. With nanolearning, concepts and principles in Chemistry is presented using multimedia instructional materials. The nanolearning multimedia instructional materials serves as a bridge and a channel for both teachers and students to achieve the goal of teaching and learning. These instructional materials are used to get the attention of the learners and to reduce boredom during class discussion (Umar et al., 2019). By taking these actions, crafting effective instructional materials can actively engage learners in the learning process.

In light of these benefits, this study investigates the use of nanolearning in Chemistry instruction to assess its potential for enhancing and improving student engagement and knowledge acquisition. By examining the effects of nanolearning in a Chemistry class, the research aims to contribute in enhancing teaching method that is accessible and effective in contemporary educational environments.

**1.1 Statement of the Problem**

*Problem/s which were addressed by the research*

This study aimed to investigate the utilization of nanolearning instructional materials in enhancing students’ engagement and knowledge acquisition in chemistry class, addressing the demand for more efficient and effective teaching approaches in science education.

Specifically, it sought to answer the following problems:

1. What is the level of acceptance of nanolearning materials with regard to:
  - 1.1 Content;
  - 1.2 Format;
  - 1.3 Conciseness; and
  - 1.4 Usability?
2. What is the level of students’ engagement of the control and experimental groups in terms of:
  - 2.1 Cognitive Engagement;
  - 2.2 Behavioral Engagement; and
  - 2.3 Emotional Engagement?
3. What is the level of students’ knowledge acquisition of control and experimental groups in terms of:
  - 3.1 Initial Science Competency Test; and
  - 3.2 End-of-Instruction Science Test?
4. Is there a significant difference in the level of student engagement in control and experimental groups?
5. Is there a significant difference in the initial science competency test in control and experimental groups?
6. Is there a significant difference in the end-of-instruction science test in control and experimental groups?

**II. METHODOLOGY**

The researcher used a quasi-experimental design with 80 Grade 8 students split into control and experimental groups via stratified random sampling. Validated nanolearning materials, surveys, and assessments measured engagement and knowledge on a 5-point Likert scale. Data from science tests were analyzed using mean, standard deviation, and t-tests to identify significant differences.

**III. RESULTS AND DISCUSSION**

The various findings from treating the data collected in this study were presented and discussed in this section. All specific questions in Chapter 1 under the statement of the problem were answered in this chapter supported by tables. It presents the data gathered about the significant relationship between learner acceptance of nanolearning materials and students’ engagement of the control and experimental groups. In particular, the study sought to address the following:

*Level of Learners Acceptance of Nanolearning Instructional Materials*

The study utilized nanolearning instructional materials in multimedia form to help learners achieve the learning competencies in Chemistry class. In this study, the level of acceptance of nanolearning instructional materials refers to Content, Format, Conciseness, and Usability. These components are vital and must be considered in the test of

reliability of the materials before the implementation of nanolearning.

The following tables shows the statements, mean, standard deviation, remarks and verbal interpretation from the perspective of the respondents.

The first table shows the level of acceptance of nanolearning instructional materials in terms of content. The data exhibits that all five statements sustained “strongly agree” responses, with mean scores from 4.57 to 4.66. The overall weighted mean of all the statements for the domain content is 4.65 (SD= 0.56), with a verbal interpretation as “very high”.

TABLE 1. Level of Acceptance of Nanolearning Instructional Materials in Terms of Content

Statements	Mean	SD	Remarks
The learning materials provide relevant information.	4.59	0.69	Strongly Agree
The learning materials cover all the essential information, ensuring a thorough understanding of key concepts.	4.62	0.61	Strongly Agree
The explanations in the content are easy to understand.	4.57	0.53	Strongly Agree
The content is presented in an engaging manner that captures interest and sustains attention.	4.66	0.48	Strongly Agree
The content is appropriately designed for the Grade 8 level, aligning with the curriculum standards.	4.66	0.48	Strongly Agree
<b>Weighted Mean</b>	<b>4.65</b>		
<b>SD</b>	<b>0.56</b>		
<b>Verbal Interpretation</b>	<b>Very High</b>		

The findings of this study indicate that the nanolearning instructional materials are presented in an engaging and interactive manner, which significantly enhances learners’ interest in the subject matter. As shown in Table 1, the content of these materials is appropriately tailored to the Grade 8 level and is closely aligned with the prescribed curriculum standards. This alignment ensures that the materials not only stimulate student curiosity but also meet the required educational benchmarks. By focusing on essential concepts and presenting them clearly, the content supports both cognitive development and curriculum mastery. The structure and clarity of the content also help avoid confusion, thereby promoting a more focused and effective learning experience for students.

These findings are supported by Khlaif and Salha (2021), who emphasized that designing and delivering educational tools in small, manageable units—following nanolearning principles—facilitates the development of effective e-learning content. Their research highlights how nanolearning materials, when well-designed, can address learners’ cognitive needs while maintaining curriculum relevance. In the context of this study, the nanolearning instructional materials do not merely convey information but ensure depth and accuracy, covering all critical content areas in a concise yet comprehensive format. This approach not only aids in the retention of knowledge but also minimizes the likelihood of misconceptions. Therefore, the quality and appropriateness of content play a crucial role in the success of nanolearning strategies, as both the present findings and the supporting literature affirm.

Table 2 presents the level of acceptance of nanolearning instructional materials in terms of format, based on the responses of validators. The table below highlights five important statements evaluated by respondents, all receiving high mean scores between 4.52 and 4.66, which are interpreted as “strongly agree.” The statements under format have a weighted mean of 4.60, with a standard deviation of 0.58. These values indicate that the nanolearning instructional materials, in terms of format, have a “very high” level of acceptance. This implies that the design, structure, and visual organization of the materials are not only appropriate but also contribute positively to the user experience. A well-structured format enhances learner comprehension and sustains engagement.

TABLE 2. Level of Acceptance of Nanolearning Instructional Materials in Terms of Format

Statements	Mean	SD	Remarks
The layout and design of the videos is visually appealing.	4.57	0.69	Strongly Agree
The videos are well-organized and easy to follow.	4.54	0.59	Strongly Agree
The multimedia elements (e.g., text, graphics, animations) enhance my understanding of the content.	4.52	0.57	Strongly Agree
The length of each video is just right for Grade 8 level attention span.	4.57	0.53	Strongly Agree
The design of the video is suitable for cellphone, tablet, and computer use.	4.66	0.48	Strongly Agree
<b>Weighted Mean</b>	<b>4.60</b>		
<b>SD</b>	<b>0.58</b>		
<b>Verbal Interpretation</b>	<b>Very High</b>		

The “very high” verbal interpretation in terms of format implies that the nanolearning instructional materials were perceived as highly effective by the respondents. Specific aspects such as visual appeal, design and layout, organization, inclusion of multimedia elements, appropriate video length, and compatibility across devices were all deemed successful. These results imply that the structural and visual components of the materials aligned well with the learners’ preferences and learning needs, which likely contributed to increased engagement and a more accessible learning experience. The effectiveness of these design elements highlights the critical role of thoughtful formatting in the delivery of instructional content, especially when utilizing technology-based approaches like nanolearning.

Table 3 presents the level of acceptance of the nanolearning instructional materials in terms of conciseness.

The data reveal that all key indicators under this variable received consistently high mean scores, ranging from 4.49 to 4.69. The overall weighted mean of 4.62, with a standard deviation of 0.55, indicates a strong consensus among respondents. These results indicate that the respondents “strongly agree” that the nanolearning instructional materials are concise, well-structured, and easy to understand, reflecting the clarity and precision of the content delivered through this format.

The obtained values from the weighted mean and standard deviation indicate a “very high” level of conciseness in the nanolearning instructional materials. With a high mean score

( $M=4.56$ ,  $SD=0.67$ ), the respondents affirmed that the materials were presented in a clear and concise manner. The content was streamlined, avoiding unnecessary or redundant information ( $M=4.49$ ,  $SD=0.60$ ), which enabled learners to concentrate better on the essential concepts in Chemistry. This clarity and focus in presentation facilitated improved comprehension ( $M=4.67$ ,  $SD=0.51$ ) and retention of key ideas ( $M=4.57$ ,  $SD=0.50$ ), while also fostering an engaging learning experience ( $M=4.69$ ,  $SD=0.47$ ). These results affirm that when instructional materials are purposefully designed to deliver targeted content in a compact and digestible format, students are more likely to engage deeply with the material and grasp complex scientific ideas more effectively.

TABLE 3. Level of Acceptance of Nanolearning Instructional Materials in Terms of Conciseness

Statements	Mean	SD	Remarks
The learning materials present information in a clear and concise manner.	4.56	0.67	Strongly Agree
The content focuses on essential details to avoid redundant information.	4.49	0.60	Strongly Agree
The concise nature of the materials allows for better focus and improved comprehension of key concepts.	4.67	0.51	Strongly Agree
The materials’ concise nature promotes retention of information more effectively.	4.57	0.50	Strongly Agree
The concise nature of content brings about the desired level of engagement.	4.69	0.47	Strongly Agree
<b>Weighted Mean</b>	<b>4.62</b>		
<b>SD</b>	<b>0.55</b>		
<b>Verbal Interpretation</b>	<b>Very High</b>		

These findings align with the study conducted by Rifandi et al. (2021), which emphasized the value of concise learning resources in enhancing student motivation and academic engagement. Their research demonstrated that learning materials that are both concise and current enable learners to stay focused and motivated, as they eliminate cognitive overload caused by excessive or irrelevant information. In the context of nanolearning, this principle becomes even more relevant, as the instructional approach centers on delivering content in bite-sized, targeted modules. The results of the current study reflect the same instructional advantage described by Rifandi et al., where focused content promotes attention, strengthens comprehension, and leads to better mastery of competencies. This demonstrates how conciseness, when strategically applied in nanolearning design, becomes a powerful element in driving student learning outcomes and sustaining meaningful engagement in the classroom.

Table 4 clearly demonstrates the level of acceptance of nanolearning instructional materials in terms of usability, showing the perceptions of the respondents. All the statements received a “strongly agree” remarks, resulting to a “very high” verbal interpretation.

These interpretations were based on the accumulated weighted mean ranging from 4.59 to 4.72 with a weighted mean of 4.68 and a standard deviation of 0.54. Overall, in terms of usability, the nanolearning instructional materials is user-friendly, can navigate easily, interesting, useful and helpful, and facilitates easy comprehension and learning.

TABLE 4. Level of Acceptance of Nanolearning Instructional Materials in Terms of Usability

Statements	Mean	SD	Remarks
The materials are easily accessible and user-friendly.	4.64	0.66	Strongly Agree
The materials are easy to navigate allowing users to quickly search the needed information.	4.72	0.55	Strongly Agree
The materials are interesting and easy to follow.	4.69	0.50	Strongly Agree
The learning materials are useful and very helpful.	4.62	0.49	Strongly Agree
The structure of the content makes it easy to follow along and absorb the material.	4.59	0.50	Strongly Agree
<b>Weighted Mean</b>	<b>4.68</b>		
<b>SD</b>	<b>0.54</b>		
<b>Verbal Interpretation</b>	<b>Very High</b>		

The very high acceptance of nanolearning instructional materials in terms of usability highlights their effectiveness as a tool for enhancing science education. This high level of usability reflects that the materials were visually clear, accessible, user-friendly, interesting, and easy to absorb—features that are essential in creating an effective and engaging learning experience. When students find educational resources easy to navigate and understand, they are more likely to engage deeply with the content and retain information more effectively.

This aligns with the core principles of learner-centered instruction, where tools are designed to support students' cognitive load and focus on meaningful content. The positive reception of the nanolearning materials in this study reinforces the importance of designing digital resources that accommodate learners' preferences and needs, particularly in content-heavy subjects like chemistry.

This finding is supported by the study of Rivera (2022), where the majority of respondents reported high acceptance of video-based instructional materials due to their ease of use and perceived usefulness. Rivera's results showed that these video-based resources positively impacted students' overall learning experience, demonstrating how multimedia elements can enhance comprehension and engagement. The consistency between Rivera's study and the current research confirms that when instructional materials—whether video-based or nanolearning modules—are thoughtfully designed for usability, they can significantly enrich the educational experience. This parallel emphasizes the growing relevance of digital learning tools in modern education and underlines the value of continuous innovation in instructional design to meet the evolving needs of students.

The very high acceptance of nanolearning instructional materials in terms of usability indicates that teacher may use this innovative tool in delivering lessons in science education. The usability of nanolearning instructional materials is important for creating effective learning experiences. It is easy for the students to use the materials if it is visually clear, accessible, user-friendly, interesting and easy to follow, helpful, and easy to follow along and absorb the material.

Table 5 presents the composite data on the level of acceptance of nanolearning instructional materials based on four key indicators: content, format, conciseness, and

usability. The results indicate a very high level of acceptance of nanolearning instructional materials across all evaluated indicators—Content (M = 4.65, SD = 0.56), Format (M = 4.60, SD = 0.58), Conciseness (M = 4.62, SD = 0.55), and Usability (M = 4.68, SD = 0.54). The computed grand mean of 4.64 with a standard deviation of 0.56 supports the overall interpretation of Very High.

TABLE 5. Composite Table of the Level of Acceptance of Nanolearning Instructional Materials

Indicators	Weighted Mean	SD	Verbal Interpretation
Content	4.65	0.56	Very High
Format	4.60	0.58	Very High
Conciseness	4.62	0.55	Very High
Usability	4.68	0.54	Very High
<b>Grand Mean</b>	<b>4.64</b>		
<b>SD</b>	<b>0.56</b>		
<b>Verbal Interpretation</b>	<b>Very High</b>		

The results indicate a very high level of acceptance of nanolearning instructional materials across all evaluated indicators—Content (M = 4.65, SD = 0.56), Format (M = 4.60, SD = 0.58), Conciseness (M = 4.62, SD = 0.55), and Usability (M = 4.68, SD = 0.54). The computed grand mean of 4.64 with a standard deviation of 0.56 supports the overall interpretation of Very High.

It is evident from the results that respondents expressed strong agreement regarding the effectiveness, clarity, and usability of the nanolearning instructional materials. This high level of acceptance suggests that the materials were well-designed, thoughtfully structured, and easy to comprehend and navigate. The consistently high ratings across all indicators—content, format, conciseness, and usability—imply that the materials not only met the learners' expectations but also facilitated a smooth and engaging learning experience. Such positive feedback reflects the participants' satisfaction with both the instructional design and the overall presentation, affirming the appropriateness of nanolearning as an effective educational strategy in the given context.

*Level of Students' Engagement of the Control and Experimental Groups*

This study examines the level of student engagement in both the control and experimental groups, focusing on three key dimensions: cognitive engagement, behavioral engagement, and emotional engagement.

Table 6 shows that the control group, taught through traditional methods, demonstrated generally high levels of engagement across cognitive, behavioral, and emotional domains, based on the weighted means and standard deviations of their responses.

In contrast, the experimental group, which utilized nanolearning instructional materials, achieved a very high level of cognitive engagement, as evidenced by a higher weighted mean of 4.33 and a standard deviation of 0.75. The responses ranged from 4.23 to 4.40 across all indicators, consistently demonstrating strong agreement with cognitive engagement statements. Students in this group reported a stronger ability to think deeply about complex Chemistry topics (M=4.23, SD=0.62), better understanding of

challenging concepts ( $M=4.40$ ,  $SD=0.71$ ), and a more meaningful connection between the lesson content and real-life scenarios ( $M=4.28$ ,  $SD=0.78$ ). Additionally, the students noted that the structured, concise format of nanolearning modules significantly helped them remain focused and absorb

content effectively. These results indicate that the nanolearning approach fosters deeper cognitive processing and sustained engagement—key factors in effective science education.

TABLE 6. Level of Students' Engagement of the Control and Experimental Groups in Terms of Cognitive Engagement

Statements	Control Group		Remarks	Experimental Group		Remarks
	Mean	SD		Mean	SD	
I find myself thinking deeply about the concepts presented in the learning materials.	3.78	0.77	Agree	4.23	0.62	Strongly Agree
The learning materials help me understand complex chemistry topics more effectively.	4.10	0.87	Agree	4.40	0.71	Strongly Agree
I can relate the content of the learning materials to real-life situations, making the lessons more meaningful.	3.70	0.85	Agree	4.28	0.72	Strongly Agree
Using learning materials helps me stay focused and engaged during chemistry lessons.	4.38	0.70	Strongly Agree	4.40	0.74	Strongly Agree
The structured and concise nature of the learning materials improves my ability to remember chemistry concepts.	4.13	0.77	Agree	4.33	0.73	Strongly Agree
<b>Weighted Mean</b>	<b>4.01</b>			<b>4.33</b>		
<b>SD</b>	<b>0.83</b>			<b>0.70</b>		
<b>Verbal Interpretation</b>	<b>High</b>			<b>Very High</b>		

TABLE 7. Level of Students' Engagement of the Control and Experimental Groups in Terms of Behavioral Engagement

Statements	Control Group		Remarks	Experimental Group		Remarks
	Mean	SD		Mean	SD	
I actively participate in class discussions after engaging with the learning materials.	3.78	0.80	Agree	4.28	0.72	Strongly Agree
I consistently read and review the provided learning materials to enhance my understanding.	3.60	0.81	Agree	4.15	0.70	Agree
The format motivates me to pay more attention during chemistry class.	4.00	0.93	Agree	4.25	0.87	Strongly Agree
I am more engaged in group activities.	4.08	1.10	Agree	4.48	0.72	Strongly Agree
After using the learning materials, I find myself more interested in studying chemistry outside of class.	3.93	0.97	Agree	4.18	0.75	Agree
<b>Weighted Mean</b>	<b>3.88</b>			<b>4.27</b>		
<b>SD</b>	<b>0.93</b>			<b>0.75</b>		
<b>Verbal Interpretation</b>	<b>High</b>			<b>Very High</b>		

The comparison of weighted means clearly shows that the experimental group outperformed the control group in all areas of cognitive engagement. The experimental group's weighted mean of 4.33 stands higher than the control group's 4.01, demonstrating the enhanced effectiveness of nanolearning materials in promoting deeper engagement with Chemistry content.

These findings are consistent with the study of Lei et al. (2018), who emphasized that cognitive engagement plays a crucial role in academic achievement and that access to well-designed, comprehension-focused materials can significantly improve students' information processing. The use of nanolearning modules in this research aligns with this insight, as students exposed to this approach showed greater ability to relate content to real-life situations, focus on learning tasks, and understand complex topics.

Table 7 displays the level of students' engagement of the control and experimental groups in terms of behavioral engagement. The control group, which followed the traditional teaching approach, exhibited relatively high behavioral engagement, though it was slightly lower than that of the experimental group.

Students in this group showed engagement scores ranging from 3.60 to 4.08 across the five key statements, with a weighted mean of 3.88 ( $SD = 0.93$ ), which was interpreted as "high." In particular, when considering active participation in class discussions, the control group recorded a mean of 3.78 ( $SD = 0.80$ ), indicating that the students agreed that traditional teaching methods contributed positively to their behavioral engagement.

Conversely, the experimental group, which utilized nanolearning instructional materials, demonstrated significantly higher behavioral engagement. The students in this group showed mean scores ranging from 4.15 to 4.48, yielding a weighted mean of 4.27 ( $SD = 0.75$ ), which was interpreted as "very high" engagement. Specifically, when asked about active participation in class discussions, the experimental group reported a mean score of 4.28 ( $SD = 0.72$ ), with students strongly agreeing that nanolearning instructional materials enhanced their behavioral engagement. This outcome highlights the positive impact of nanolearning on fostering greater student interest, participation, and active involvement in their chemistry lessons.

A comparison of the weighted means of the two groups clearly indicates a marked difference in behavioral

engagement levels. The experimental group, exposed to nanolearning instructional materials, achieved a higher weighted mean of 4.27, while the control group, which followed traditional teaching methods, had a mean of 3.88.

This disparity highlights the greater effect of nanolearning on student participation, notably in the field of chemistry instruction. The positive engagement in both groups, particularly in statements two and five, indicates that both traditional and nanolearning methods positively influenced behavioral engagement.

Table 8 depicts the level of students' engagement in Chemistry class in terms of emotional engagement. Following the integration of the nanolearning instructional resources, the following table compares the data between the control group and the experimental groups.

TABLE 8. Level of Students' Engagement of the Control and Experimental Groups in Terms of Emotional Engagement

Statements	Control Group		Remarks	Experimental Group		Remarks
	Mean	SD		Mean	SD	
I feel excited about learning chemistry when I use the learning materials.	3.75	0.95	Agree	4.45	0.64	Strongly Agree
The activities make me feel more confident in my ability to understand matter.	4.03	0.95	Agree	4.30	0.65	Strongly Agree
The learning materials helps me feel less anxious about difficult concepts.	3.83	0.90	Agree	4.35	0.58	Strongly Agree
It helps me better manage the information without feeling overwhelmed.	3.88	0.82	Agree	4.43	0.64	Strongly Agree
I feel emotionally connected to the lessons when using the learning materials.	3.73	0.91	Agree	4.20	0.79	Strongly Agree
<b>Weighted Mean</b>			<b>3.84</b>	<b>4.35</b>		
<b>SD</b>			<b>0.90</b>	<b>0.66</b>		
<b>Verbal Interpretation</b>			<b>High</b>	<b>Very High</b>		

The experimental group, on the other hand, demonstrated consistently higher scores across all emotional engagement indicators, leading to a weighted mean of 4.35 and a standard deviation of 0.66, verbally interpreted as "very high." This group showed strong agreement that the nanolearning instructional materials helped increase their excitement toward learning Chemistry and boosted their confidence in understanding complex topics. Learners also responded more positively regarding their ability to manage information and their emotional connection to the lessons. Notably, the lower standard deviation values reflect greater consistency in responses, which indicates that the emotional benefits of using nanolearning materials were experienced broadly among students in the experimental group.

The difference in the weighted mean scores between the control and experimental groups highlights the enhanced emotional engagement experienced by students exposed to nanolearning. While both groups benefited emotionally from their respective learning experiences, the structured, accessible, and visually engaging format of nanolearning materials appears to have fostered a more emotionally resonant learning environment.

This outcome is in line with the findings of Rusi et al. (2024), who emphasized the statistical significance of emotional engagement in academic performance. Their study showed that emotional engagement plays a crucial role in students' success, aligning with the present findings, where the experimental group not only maintained focus and confidence but also demonstrated a stronger emotional connection to the subject through the use of nanolearning materials in Chemistry.

The control group, which was taught through traditional instruction, demonstrated a generally high level of emotional engagement based on the weighted mean score of 3.48 with a standard deviation of 0.90. This level is verbally interpreted as "high," indicating that even without the integration of nanolearning materials, learners were still able to remain emotionally involved in their Chemistry lessons. Across the five emotional engagement indicators—excitement about learning, confidence in understanding, reduced anxiety, ability to manage information, and emotional connection—students in the control group consistently agreed with the positive statements. Although the scores remained in the "agree" range, the standard deviations reflected a wider distribution of responses, which may indicate variability in how traditional instruction impacted individual learners' emotional experiences.

Table 9 presents a comparison of the level of students' engagement between the control and experimental groups across three indicators: cognitive, behavioral, and emotional engagement. The experimental group achieved a grand mean of 4.32 (SD = 0.70), which falls under the Very High category. This indicates that students who were exposed to the nanolearning instructional materials demonstrated very high levels of engagement in all three dimensions. In contrast, the control group recorded a grand mean of 3.91 (SD = 0.89), interpreted as High, suggesting relatively lower engagement levels among students who did not use the nanolearning materials. These results imply that the nanolearning approach had a positive impact on enhancing student engagement.

TABLE 9. Composite Table on the Level of Students' Engagement of the Control and Experimental Groups

Indicators	Control Group		Remarks	Experimental Group		Remarks
	WM	SD		WM	SD	
Cognitive Engagement	4.01	0.83	High	4.33	0.70	Very High
Behavioral Engagement	3.88	0.93	High	4.27	0.75	Very High
Emotional Engagement	3.84	0.90	High	4.35	0.66	Very High
<b>Grand Mean</b>			<b>3.91</b>	<b>4.32</b>		
<b>SD</b>			<b>0.89</b>	<b>0.70</b>		
<b>Verbal Interpretation</b>			<b>High</b>	<b>Very High</b>		

This indicates that the integration of nanolearning instructional materials in Chemistry class had a positive effect on students' engagement in three indicators—cognitive, behavioral, and emotional compared to the traditional learning materials used in the control group.

Table 10 depicts the level of students' knowledge acquisition of control group. The initial science competency test and end-of-instruction science test exhibits the changes in terms of students' performance in Chemistry class who were exposed to traditional instruction.

Most of the students in the initial science competency test scored between 9-16 (55%) which is interpreted as "fairly satisfactory", 35% of the students scored between 17-24 has a verbal interpretation of "satisfactory" and the remaining 10% of the students from the control group score between 0-8 points, indicating they "did not meet expectations". None of the students scored "very satisfactory" and outstanding" in the initial science competency test.

TABLE 10. Level of Students' Knowledge Acquisition of Control Group

Score	Initial Science Competency Test		End-of-Instruction Science Test		Descriptive Equivalent
	f	%	f	%	
33 - 40	0	0.00	2	5.00	Outstanding
25 - 32	0	0.00	2	5.00	Very Satisfactory
17 - 24	14	35.00	19	47.50	Satisfactory
9 - 16	22	55.00	17	42.50	Fairly Satisfactory
0 - 8	4	10.00	0	0.00	Did not meet Expectation
<b>Total</b>	<b>40</b>	<b>100</b>	<b>40</b>	<b>100</b>	
<b>Weighted Mean</b>	13.80		18.10		
<b>SD</b>	4.496		5.472		
<b>Verbal Interpretation</b>	Fairly Satisfactory		Satisfactory		

However, after using the traditional instruction, there was a slight increase in the scores of the students. The percentage of students who obtained "satisfactory" level was 47.5% which means that there was a quite improvement in their performance. These students scored between 17-24 points in the end-of-instruction science test. Only 5% of the class was categorized as "outstanding" and "very satisfactory" which was not observed in the initial science competency test. Lastly, 42.5 % remained in the "fairly satisfactory" category. Additionally, there has been an improvement in the weighted mean from 13.80 (initial science competency test) to 18.10 (end-of-instruction science test) which reveals improvement in knowledge acquisition of the control group. In terms of standard deviation, there was also an increase from 4.496 to 5.472, indicating that there were differences in students' performance after the traditional instruction. These findings only convey that there was a moderate progress in the traditional instruction.

These findings can be supported by the study of Sezer (2017) which connotes that academic achievement varies to the method applied in teaching.

Posttest and pretest were also conduct in the study to measure the level of students' academic achievement. Similarly, in this study, a pretest and posttest were conducted to be able to measure the level of knowledge acquisition of control and experimental group.

The data in table 11 shows the level of students' knowledge acquisition of the experimental group exposed with nanolearning instructional materials.

TABLE 11. Level of Students' Knowledge Acquisition of Experimental Group

Score	Initial Science Competency Test		End-of-Instruction Science Test		Descriptive Equivalent
	f	%	f	%	
33 - 40	0	0.00	3	7.50	Outstanding
25 - 32	0	0.00	14	35.00	Very Satisfactory
17 - 24	9	22.50	18	45.00	Satisfactory
9 - 16	28	70.00	5	12.50	Fairly Satisfactory
0 - 8	3	7.50	0	0.00	Did not meet Expectation
<b>Total</b>	<b>40</b>	<b>100</b>	<b>40</b>	<b>100</b>	
<b>Weighted Mean</b>	13.15		21.53		
<b>SD</b>	3.880		5.598		
<b>Verbal Interpretation</b>	Fairly Satisfactory		Satisfactory		

Students who took the initial science competency test in Chemistry obtained a weighted mean of 13.15 (SD= 3.880) interpreted as "fairly satisfactory" which means that students had some knowledge of the topic but lack deeper understanding. From the initial science competency test, 22.50% or 9 out of 40 students who took the test got "satisfactory" rating. The percentage of students who got "fairly satisfactory is 70% or 28 out of 40 students, and the remaining 7.50% of the class who took the test "did not meet expectation".

However, after the integration of nanolearning instructional materials, there was a notable increase in the weighted mean which obtained 21.53 and higher standard deviation of 5.598, interpreted as "satisfactory". With these values, students' performance level in Chemistry increased with the aid of nanolearning instructional materials.

Out of 40 students, 3 students or 7.50% attained "outstanding level" while 35% or 14 students who took the test reached "very satisfactory" level showing a remarkable enhancement in terms of knowledge acquisition of Chemistry concepts. In the "satisfactory" level, a significant increase was noticed with 45% or 18 students achieved this level compared to 9 students (22.50%) in the initial science competency test.

Despite the significant increase in satisfactory level, few students were still in the "fairly satisfactory" category. But, a decreased percentage in this category has a significant impact for the students, indicating improved knowledge acquisition.

Promoting the use of videos as instructional material, leads to better test results (Forster et al., 2022). They also expound that prior watching video lesson, leads to better knowledge retention. Thus, developing various forms of instructional materials like nanolearning videos can improve knowledge acquisition, understanding and also retention of information.

Lastly, after taking the end-of-instruction science test, none of the students was categorized in "did not meet expectation", indicating that all students improved their knowledge acquisition after utilizing nanolearning materials.

*Test of Difference on the Students' Engagement in Control and Experimental Groups*

To test the significant difference between the students' engagement of the control and experimental groups they were treated statistically using Real Statistics Data Analysis Tools

using the Test of difference. The data in table 12 presents the test of difference of the students' cognitive, behavioral, and emotional engagement of the control and experimental groups.

TABLE 12. Test of Difference on the Students' Engagement of the Control and Experimental Groups

Students' Engagement	C G		E G		M D	95% Confidence Interval of Difference		t	df	Sig (2-tailed)
	M	SD	M	SD		L	U			
Cognitive Engagement	4.01	0.83	4.33	0.70	0.316	0.28	0.35	2.372	39	0.0227
Behavioral Engagement	3.88	0.93	4.27	0.75	0.390	0.23	0.47	2.920	39	0.0058
Emotional Engagement	3.84	0.90	4.35	0.66	0.505	0.23	0.55	3.775	39	0.0005

Legend: \*Significant at 0.05

TABLE 13. Test of Difference on the Students' Knowledge Acquisition of the Control and Experimental Groups in Initial Science Competency Test

Students' knowledge acquisition	CG		EG		MD	95% Confidence Interval of Difference		t	df	Sig (2-tailed)	
	M	SD	M	SD		L	U				
Initial Science Competency Test	13.80	4.496	13.15	3.880	0.650	15.05		20.22	0.715	39	0.4788

Legend: \*Significant at 0.05

In terms of cognitive engagement, the results indicate that the experimental group outperformed the control group, with a mean difference of 0.316, a t-value of 2.372, and a p-value of 0.0227. These values statistically confirm that students who were exposed to nanolearning instructional materials experienced a higher level of engagement in cognitive tasks. This increase reflects how the integration of concise, visually engaging, and interactive content in nanolearning helped students focus better, process information more efficiently, and participate in mentally challenging academic activities. The structured format of the materials likely contributed to sustaining attention and deepening understanding, which are core components of cognitive engagement in science learning.

For behavioral engagement, a similar pattern emerged. The experimental group recorded a higher mean score (M = 4.27, SD = 0.75) compared to the control group (M = 3.88, SD = 0.93), with a mean difference of 0.390. The corresponding t-value of 2.920 and p-value of 0.0058 indicate a statistically significant difference. This outcome points to a noticeable shift in students' participation, effort, and involvement in learning activities following the integration of nanolearning. The bite-sized and manageable format of the instructional materials likely encouraged consistent interaction with the lesson content, promoting increased class engagement, task completion, and motivation to learn.

In the emotional engagement, the experimental group again outscored the control group, with a mean of 4.35 (SD = 0.66) versus 3.84 (SD = 0.90), yielding a mean difference of 0.505. The t-value of 3.775 and the p-value of 0.0005 strongly indicate a statistically significant improvement in emotional engagement among students using nanolearning materials. Students in this group reported feeling more excited, confident, and less anxious when engaging with Chemistry lessons. The emotionally supportive and visually accessible structure of nanolearning likely created a positive learning environment where students felt connected to the material and more self-assured in navigating complex topics.

Overall, the data highlight the holistic impact of nanolearning across the three domains of student engagement—cognitive, behavioral, and emotional. This comprehensive improvement aligns with Geertshuis (2019), who emphasized that emotional engagement shapes student

behaviors and fosters positive learning attitudes. When students feel emotionally connected, it often translates into more active participation and better academic performance.

Similarly, Liu et al. (2022) pointed out that emotional and cognitive engagements are closely linked, reinforcing one another to create a supportive learning space. In the context of this study, the integration of nanolearning instructional materials did more than just deliver content—it cultivated a learning experience that motivated students, encouraged participation, and deepened their cognitive involvement in science education.

*Test of Difference on the Students' Knowledge Acquisition of the Control and Experimental Groups in Initial Science Competency Test*

To test the significant difference between the students' knowledge acquisition of the control and experimental groups, they were treated statistically using Real Statistics Data Analysis Tools using the Test of difference.

Table 13 shows the results of the initial science competency test conducted to assess the prior knowledge of both the control and experimental groups before the introduction of nanolearning instructional materials. The control group obtained a mean score of 13.8 (SD = 4.496), while the experimental group recorded a slightly lower mean of 13.15 (SD = 3.880). The computed mean difference of 0.650, with a t-value of 0.715 and a p-value of 0.4788, indicates that the observed difference in scores is not statistically significant at the 0.05 level.

This finding confirms that both groups began the study with comparable levels of understanding in science concepts. By establishing that there was no significant difference in their baseline knowledge, the study ensures that any variation observed in the end-of-instructions science test results can be more confidently attributed to the learning intervention—in this case, the use of nanolearning materials.

To support the findings, the present study has a connection to the study conducted by Bhattacharjee (2016), that pretest is a standard practice which ensures that control group and experimental group will be treated equally. It is important that an initial science competency test must be taken by the students in Chemistry before doing the intervention.

The result of the test of difference on the students' knowledge acquisition of the control group and experimental groups in initial science competency test indicates equal level of prior knowledge among students of Grade 8 in Chemistry. It is also evident that the results from two groups show no significance.

*Test of Difference on the Students' Knowledge Acquisition of the Control and Experimental Groups in End-of-Instruction Science Test*

To test the significant difference between the students' knowledge acquisition of the control and experimental groups, they were treated statistically using Real Statistics Data Analysis Tools with the Test of Difference. The results were carefully analyzed to determine the effectiveness of the intervention, comparing the means of both groups to assess whether the treatment had a statistically significant impact on knowledge acquisition. The data presented in Table 14 shows a clear distinction in the level of knowledge acquisition between the control and experimental groups as measured by the end-of-instruction science test. Students in the control group obtained a mean score of 18.10 (SD = 5.472), reflecting a moderate level of understanding following traditional instruction. In contrast, students in the experimental group, who were exposed to nanolearning instructional materials, achieved a higher mean score of 23.53 with a standard deviation of 5.598. This noticeable increase in performance demonstrates a stronger grasp of the science concepts covered during the instruction period.

TABLE 14. Test of Difference on the Students' Knowledge Acquisition of the Control and Experimental Groups in End-of-Instruction Science Test

Students' knowledge acquisition	Control Group		Experimental Group		Mean Difference	95% Confidence Interval of Difference		t
	M	SD	M	SD		L	U	
End-of-Instruction Science Test	18.10	5.472	23.53	5.598	5.425	29.94	31.33	4.433

Legend: \*Significant at 0.05

The computed mean difference of 5.425 between the two groups, along with a t-value of 4.43 and a p-value of 0.0001, indicates that the difference in performance is statistically significant. The p-value being far below the 0.05 threshold confirms that the improvement observed in the experimental group is unlikely due to chance. These findings support the effectiveness of nanolearning in enhancing students' knowledge acquisition, as the learners who engaged with this method performed substantially better than those who received conventional teaching. The results emphasize the potential of nanolearning strategies in improving content mastery and academic outcomes in science education.

These results align with the findings of Loh et al. (2019), who emphasized that nanolearning videos helped the students to understand lessons and most of the students who took the survey on the use of nanolearning videos were able to fully or mostly understand the content of the video. This signifies that

the use of nanolearning instructional materials, through video format can enhance students' level of knowledge acquisition.

Similarly, Vergara-Barberan et al. (2023) found that there is a positive learning experience that helped the students to better understand selected topics. In addition, the student generated nanolearning materials, in a form of TikTok videos increased student motivation.

Therefore, the findings of this study support the capability of nanolearning instructional materials to improve and enhance students' knowledge acquisition in Chemistry of grade 8 level and in science education as a whole. This innovative undertaking will not just help the students in learning but also for the teachers who are spending more time in lectures and teachers will have more time to track students' progress in real time.

IV. CONCLUSION AND RECOMMENDATIONS

Based on the analysis of student engagement levels between the control and experimental groups, it was inferred that there is a significant difference between the students' engagement of the control and experimental groups, resulting to rejecting the null hypothesis. This means that students who experience the use of nanolearning instructional materials tend to enhance their cognitive, behavioral, and emotional engagement in Chemistry class.

The null hypothesis stating that there is no significant difference in knowledge acquisition between the control and experimental groups in the initial science competency test was accepted. This incites that the control and experimental groups have the same level of prior knowledge in Chemistry before being exposed to specific strategies and materials.

Lastly, to complete the conclusions of this study, it was also inferred that there is a significant difference between the students' knowledge acquisition of the control and experimental groups in terms of end-of-instruction science test, arising to the rejection of the null hypothesis. This indicates that there is a significant improvement in the experimental group of the study, who used the nanolearning instructional materials resulting to more enhanced student knowledge acquisition.

Based on the drawn conclusions, the following recommendations are offered:

Educators may integrate these instructional materials as it enhances then cognitive, behavioral, and emotional engagement of the students.

Educators are encouraged to utilize nanolearning instructional materials as part of their teaching strategies to enhance students' knowledge acquisition in Chemistry.

Enhance the nanolearning materials with elements that foster emotional engagement, such as the use of relatable scenarios and interactive components that may help bridge the emotional disconnect some students experience and improve overall learning effectiveness.

Integrate real-life examples and application-based tasks into nanolearning materials to improve student relevance and engagement.

Incorporate interactive elements in nanolearning materials to encourage consistent reading and review.

Lastly, further studies may be conducted to explore the long-term impact of nanolearning in different subjects.

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